CENTRE DE COOPERATION INTERNATIONALE EN RECHERCHE AGRONOMIQUE

POUR LE DEVELOPPEMENT

C I R A D

DIRECTION DES RELATIONS EXTERIEURES D R E

DEPARTEMENT FRUITIERS I R F A

RAPPORT DE MISSION AU BENIN

11 - 16 Septembre 1991

RESEARCH COORDINATION MEETING FOR BIOLOGICAL AND INTEGRATED CONTROL OF BANANA AND PLANTAIN PESTS AND DISEASES

Cotonou, Bénin, 12-14 Novembre 1991

J. L. SARAH

Service Entomologie - Nématologie

CIRAD / IRFA - B.P. 5035 - 34032 MONTPELLIER CEDEX

2

DEROULEMENT DE LA MISSION

Lundi 11 Novembre ; Départ pour Cotonou via Paris

Du mardi 12 Novembre au jeudi 14 Novembre ; Déroulement de la réunion (ANNEXE 5)

Vendredi 15 Novembre ; entretiens avec A. LASSOUDIERE (Place et besoins des disciplines entomologie et nématologie au sein du CRBP) et P. QUENEHERVE (Relations CIRAD-ORSTOM dans le domaine de la nématologie). Départ pour Paris.

Samedi 16 Novembre ; Arrivée à Montpellier via Paris.

OBJECTIFS DE LA REUNION

Cette réunion était organisée par l'IITA, en relation avec l'OUA, la FAO, l'INIBAP, l'ICIPE et le CABI.

Les intentions affichées par les organisateurs étaient de réactualiser les recommandations du groupe de travail sur les nématodes et les charançons organisé par l'INIBAP en 1987 à Bujumbura (Burundi) et de trouver les moyens de les mettre en pratique en mettant en relations les organisations nationales, régionales et internationales. Les objectifs généraux de cette réunion étaient:

1) Passer en revue les programmes en cours et l'état des connaissances sur les contraintes biotiques des systèmes extensifs de culture des bananiers en Afrique.

2) Définir les priorités de la recherche et identifier les principales contraintes aux applications des résultats.

3) Répartir les responsabilités de conduite des programmes de recherches.

Par rapport à l'objectif initial, qui était de focaliser sur les problèmes posés par les charançons des bananiers et sur les méthodes de lutte biologique contre ce ravageur, la part réservée aux nématodes et aux maladies s'est vue notablement augmentée.

Après des exposés généraux, suivis de discussions, sur les programmes et les principaux thèmes d'études (cf Annexe 5), la réunion s'est poursuivie sous forme de groupes de travail.

RESULTATS DES DISCUSSIONS

Entomologie

Résumé des discussions et des conclusions du groupe de travail

Les charançons sont généralement reconnus comme un des principaux facteurs limitant de la production d'autoconsommation dans de nombreuses situations. Pourtant ce domaine souffre d'un très grand manque de coordination entre les divers programmes menés çà et là.

Un effort dans ce sens est impératif. Celà pourrait passer par des réunions régulières des spécialistes impliqués dans les travaux de recherche, et sur une amélioration de la communication (MUSARAMA).

Bien que beaucoup d'études aient été consacrées à la biologie de ces ravageurs, et notamment de *Cosmopolites sordidus*, un des principaux facteurs limitant au développment de techniques de lutte non-chimique apparaît être le manque d'information sur l'écologie et le comportement en milieu naturel. Les études sur ces thèmes (incluant la variabilité spécifique, les relations sémio-chimiques et les interactions avec les autres déprédateurs ou pathogènes) seraient donc à privilégier.

La recherche de techniques de lutte passe en priorité par la recherche d'agents pathogènes ou de parasites, mais les techniques culturales, notamment l'utilisation de matériel de plantation sain et les rotations (je n'y crois pas trop) ou les associations culturales peuvent apporter des améliorations sensibles de l'état sanitaire. L'évaluation de la sensibilité variétale doit être accentuée notamment par la mise en place d'un International Musa Testing Program (INIBAP).

A noter les résultats obtenus sur des substances attractives isolées de bananiers (communication de M Budemberg, ICIPE, dont on attend une copie).

Problème de l'évaluation

Comme pour les autres deux autres domaines (nématodes et maladies), il y a eu de nombreuses discussions sur les techniques d'évaluation. Notamment le coefficient d'infestation jugé généralement très lourd. Toutefois la technique "simple" proposée en remplacement (comptage des galeries superficielles) ne me paraît pas sensiblement différente, ni dans le fond (type d'évaluation) ni dans la forme (la "lourdeur" me paraît équivalente). **Il serait souhaitable que M KEHE diffuse régionalement sa technique dévaluation pour démontrer son aplicabilité à nos collègues de culture anglo-saxonne.**

Nématologie

Résumé des discussions et des conclusions du groupe de travail

On trouvera en Annexe 1, la traduction française des conclusions du groupe de travail nématologie auquel je participais.

Bien que l'insuffisance de spécialistes sur le terrain soit unamiment déplorée, le réseau de relations qui s'est tissé entre les spécialistes expérimentés après la réunion de Bujumbura (CABI, CIRAD/IRFA, NRI, ORSTOM), a permis une début de coordination des recherches et une relative circulation de l'information. Ces deux points (Coordination et information) devraient s'accroître rapidement grâce à la mise sur pied de projets communs, et à une meilleure utilisation de l'outil MUSARAMA.

La connection des divers maillons travaillant actuellement sur la résistance-tolérance devraient permettre la mise en place rapide d'un IMTP sous l'égide de l'INIBAP.

Problèmes de l'évaluation

On trouvera en ANNEXE 4 le papier présenté sur le sujet et qui essaye de montrer la variété du problème. Parmi cette variabilité il conviendrait de définir une méthodologie commune, au moins pour une culture dans une zone géographique (En l'occurence la culture extensive des bananiers en Afrique). J. BRIDGE a proposé une technique d'évaluation rapide au champ (basée sur la notation des nécroses. La discussion a montré toute la difficulté de faire passer le message vis-à-vis des non-spécialistes. Cette technique simple et rapide (cf ANNEXE 4) peut être appliquée partout par tout le monde et donc donner une évaluation standardisée (avec toutefois de fort risque d'étalonnages variables - subjectivité -). Cette technique peut donc être appliquée pour des enquêtes d'évaluation préliminaires. **MAIS**, partout ou cela sera possible des méthodes d'évaluation plus sophistiquées devront être utilisées pour des études plus précises.

Pathologie

Résumé de l'exposé des conclusions du groupe de travail

Les quatre problèmes principaux sont (dans l'ordre ?) les cercosporioses, la fusariose, le Bunchy Top et la virose à tirets.

Les thèmes d'études à privilégier sont :

- La résistance aux pathogènes, avec notamment la mise au point de tests d'évaluation du germplasm (Fusariose notamment).

- Les études épidémiologiques, notamment avec la mise en évidence de facteurs limitants liés à l'environnement ou au phénotype des bananiers (Cercosposrioses).

- Favoriser les mesures prophylactiques et la distribution de matériel sain (Fusariose, Bunchy Top).

CONCLUSIONS

Cette réunion a été dans l'ensemble de moins haute tenue que celle de Bujumbura, et les conclusions qui en découlent n'offrent pas grande originalité par rapport à celles de 1987.

Toutefois le situation a évolué et des actions plus coordonnées entre organismes internationaux et régionaux-nationaux peuvent être concrètement développées rapidement. Notamment **il est important que le CRBP noue des relations avec l'IITA,** plus particulièrement dans le **domaine de l'entomologie avec le centre de Cotonou,** bien équipé et bien subventionné, **mais aussi avec l'ICIPE** dont les actions nous sont moins connues. On pourrait même se poser la question de l'utilité d'avoir deux Centres proches travaillant sur les même thèmes; un rapprochement physique ne serait-il pas envisageable ? **En nématologie le problème est différent puisque l'IITA de Cotonou ne développe pas de recherches actuellement dans ce domaine et que le CRBP dispose d'un laboratoire équipé.**

Le coordinateur régional de l'INIBAP pourrait avoir un grand rôle à jouer pour favoriser ces contacts inter-régionaux et le développement d'une stratégie régionale vraie en matière de lutte contre les ravageurs et maladies.

Pour finir, et élargir le contexte, il a été déploré un manque de contact entre spécialistes tropicaux des divers continents:

- Cette remarque ne s'applique peut-être pas à la phytopathologie. (?)
- Elle est relativement pertinente pour la nématologie et l'entomologie où les spécialistes Sud-Américains et Asiatiques n'ont que peu de contact avec leurs homologues Africains. En fait des efforts existent dans ce domaine. Au sein de l'IRFA, il y a toujours eu une bonne circulation entre Afrique, Antilles et Amérique du Sud, qui a pu s'exprimer notamment au sein des meetings de l'ACCORBAT. Mais force est de constater que la relation se fait plutôt par le trajet indirect Sud-Nord-Sud.

Montpellier, Décembre 1991

ANNEXE 1

RAPPORT DU GROUPE DE TRAVAIL NEMATOLOGIE

Peu de travaux ont été consacrés sur les nématodes attaquant les bananiers d'autoconsommation en Afrique.

Une bonne connaissance de la situation sanitaire est essentielle pour développer des stratégies de maîtrise des nématodes dans les différents systèmes culturaux.

Le groupe déplore qu'aucun spécialiste en nématologie ne travaille au sein des organisations internationales mandatées pour effectuer des recherches sur bananiers en Afrique.

Tenant compte des recommandations du groupe de travail de l'INIBAP (Bujumbura, Burundi, 1987), dont certaines sont en cours d'application, nous dressons ici la liste des priorités pour la recherche au sein des organisations Nationales et Régionales, en association avec les organisations internationales où les compétences et les appuis matériels et financiers peuvent être trouvés. Les collaborations possibles sont données entre parenthèses.

1. Programme nationaux et régionaux

(a) Une évaluation de l'importance relative des différentes espèces de nématodes présents est nécessaire dans de nombreux pays. Cet inventaire a déjà été réalisé en Tanzanie, Kenya, Côte d'Ivoire et Cameroun, il a été ébauché au Rwanda, au Burundi et au Ghana, il est en cours en Ouganda.

(b) Créer des pépinières de matériel végétal sain en utilisant les vitro-plants pour la fourniture de plants aux paysans (Supervision INIBAP).

(c) Evaluer le potentiel des différents cultivars en l'absence d'ataques.

(d) Encourager la formation en nématologie à différents niveaux:

i) diplômes Universitaires et formation post-doctorale (l'IITA soutien un étudiant en Ouganda).

ii) formation technique de courte durée, techniques nématologiques de laboratoire, identification, et évaluation au champ. (Assistance des bailleurs de fond).

(e) Evaluer les pertes les pertes attribuées aux nématodes dans différents contextes, en relations avec les autres ravageurs et maladies (cf point c). (Expertise CIRAD-IRFA / CABI-NRI / IITA).

(f) Développer les techniques de lutte intégrée, telles que résistance variétale, rotation, mulching et autres techniques culturales.

2. Organisations internationales

(a) Promouvoir la recherche en nématologie en formant et en employant du personnel qualifié.

(b) Favoriser la distribution et la disponibilité en matériel végétal sain.

(c) Etudes sur le pouvoir pathogène

i) des différentes espèces en conditions contrôlées. (CIRAD-IRFA, NRI, CABI, University of Reading).

ii) variabilité de l'espèce *Radopholus similis* et de celles du genre *Pratylenchus* (Programme soutenu par le NRI, avec participation du CABI/Rothampsted et de l'Imperial College et la collaboration du CIRAD-IRFA/Montpellier.

(d) Criblage variétal, études des mécanismes de la résistance/tolérance. (CIRAD-IRFA, NRI-University of Reading, CABI).

(e) Gestion des systèmes culturaux pour maintenir la productivité des plantains (Etudes en cours à l'IITA mais nématodes non pris en compte).

(f) Amélioration du transfert d'information, communication (INIBAP -Musarama).

(i) Mise à disposition du système d'identification des cultivars MUSAID (INIBAP, CIRAD/IRFA).

(j) Accentuer la recherche d'agents de lutte biologique notamment dans les sols paraissant défavorables aux nématodes. (CIRAD-IRFA, CABI, NRI, IITA).

ANNEXE 2

BANANA WEEVIL AND NEMATODE RESEARCH AT IITA: CURRENT NEEDS AND RESEARCH AGENDA FOR AFRICAN PLANTAIN AND HIGHLAND BANANA SYSTEMS

The International Institute of Tropical Agriculture (IITA) with headquarters in Ibadan, Nigeria, has as its principal goal increased agriculture productivity and sustainability in the humid and subhumid tropics. Plantain and highland banana (Musa types AAB and AAA) are mandate crops of the institute. IITA's plantain program is based at its high rainfall station in Onne, Nigeria and is working on the epidemiology of black sigatoka in Africa, tissue culture and development of resistant hybrids. A highland banana project has been recently established at the Kawanda Research Station near Kampala, Uganda.

IITA recognizes the importance of plantain and highland banana in Sub-Saharan Africa and realizes the need for increased research in these crops. In 1991, the institute recruited 4 additional scientists (breeder, entomologist and two pathologists) to work on plantain and banana.

The Biological Control Program (BCP) of IITA is developing complementary research projects to study banana weevils and nematodes in highland banana systems in eastern Africa and in plantain systems in western Africa. Although it is clear that pests and diseases limit plantain/highland banana production, yield loss has not been partitioned among constraints.

Therefore the first phase of the study, will concern the program's short-term objective, assessment, by definition of pest problems in banana/plantain through systems analysis and ecological studies. To do this, BCP will employ rigorous diagnostic surveys and geographic information systems data bases, supported by on-station and on-farm trials.

The second phase will concern BCP's long term objective which is to develop control strategies, including possible introduction of exotic natural enemies from the pest's presumed center of origin (south and south-east Asia).

Current studies being undertaken by IITA/BCP are primarily oriented towards banana weevil and nematodes in highland banana systems. IITA/BCP, in collaboration with the Biological Control Program of the Ugandan Ministry of Agriculture, is conducting diagnostic surveys to determine how biotic and abiotic factors influence distribution, incidence and importance of banana weevils and nematodes in Uganda.

Other research objectives include preliminary yield loss assessment, weevil/nematode/pathogen/host plant interactions, studies on nematode species profiles, identification of endemic natural enemies and monitoring of pesticide resistance in banana weevil.

Parallel surveys are proposed for plantain systems in West Africa. Ongoing research on banana weevil in plantain systems in western Africa includes feasibility studies on the use of endemic or secondary egg parasitoids for the control of banana weevil and basic research on the weevil's biology.

ANNEXE 3

THE PLANTAIN AND BANANA IMPROVEMENT PROGRAM (PBIP) OF IITA: CURRENT OBJECTIVES AND ACTIVITIES

D. Vuylsteke, Leader PBIP, Onne Station

The International Institute of Tropical Agriculture (IITA) has performed research on plantain and banana since the mid-1970s, because the crop is an integral part of the farming systems of the humid and subhumid regions of sub-Saharan Africa. Thus, early research focussed on agronomy and physiology of plantain. Since 1987, the program expanded considerably through the launching of a genetic improvement program. The establishment of this breeding program emphasizes the importance and high value of plantain and banana and acknowledges the increasing pest pressure on the crop.

There are two major biotic constraints to plantain/banana production across Africa: the black sigatoka disease and the banana weevil pest, which both are major components of the complex syndrome of plantain and banana yield decline. These issues are addressed at IITA by two research programs. The Biological Control Program (BCP) is implementing a diagnostic survey of the banana weevil in the highland banana system of East Africa as basis for investigating the feasibility of biocontrol of this pest. On the other hand, the Plantain and Banana Improvement Program (PBIP) targets the production of new plantain/banana varieties that incorporate black sigatoka (BS) resistance and the development of cultural practices for sustainable, perennial production of plantain.

PBIP has three research projects:

1. Breeding plantain/banana for durable host plant resistance to sigatoka.
Presently, 20 hybrids of plantain have been selected that combine reduced susceptibility to BS with good bunch and fruit characteristics. These hybrids are already being evaluated in multilocational testing trials. The breeding successes at IITA's Onne Station challenge the generally accepted intractability of the crop to genetic improvement.

2. Eco-pathosystem analysis of sigatoka diseases in Africa.
This project supports the breeding component by providing baseline data on host plant/pathogen interaction and epidemiology that are required for the development of durable host plant resistance. This diagnostic analysis will also provide the framework in which to assess appropriate interventions in an integrated pest management strategy.

3. Crop management practices for sustainable plantain production.
The management of organic matter in plantain fields, which is essential to perennial productivity on the poor soils of the West and Central African humid forest zone, is researched in agroforestry trials.

ANNEXE 4

ESTIMATION OF NEMATODE INFESTATION IN BANANA

J.L. SARAH

INTRODUCTION

Methods and techniques used for assessment of nematode infestations are quite varied and the choice of which one of them to use will depand on many factors such as purpose of the study and accuracy needed, cropping system, nematode species and, technical (equipment) limitations (see Southey, 1985; Hooper, 1985*a* and 1985*b*; Ferris, 1987; Seinhorst, 1988). This consideration is directly applicable to the multifaced system of banana production and estimation methods will range from direct evaluation in the field through damage assessment up to sophisticated methods of sampling and extraction.

DIRECT ESTIMATION IN THE FIELD

Nematode damage on banana can be directly assessed in the field by determining the extent of necroses on corm or roots (migratory), or gall index on roots (sedentary). A 0 to 4 scale was developed to assess the extent of necroses on banana roots (Stover, 1972). Necroses are due to both nematodes and pathogens (mainly fungi). One of these fungi, *Cylindrocladium*, is pathogenic in the absence of nematodes (Loridat & Ganry, 1989). However, the relationship between tissue necroses or galls and endoparasitic nematode infestation is usually consistent in the field.

Twice-monthly counts of uprooted plants was recommended as way of damage assessment (Tarté & Pinochet, 1981). However, this approach may be useful only in areas where uprooting is the major consequence of nematode attack, which is not the case in West Africa for instance. In addition, uprooting may be due to other pests such as weevils or to edaphic problems. In Latin America, the ratio or the weight of functional roots are commonly used (Shillingford, 1988; Perez & Gomez, 1988). However, the definition of a functional root is not clearly established and its determination is highly subjective.

Gall index is widely used on crops suceptible to root-knot nematodes. But, symptoms on banana are usually light and atypical and may be confused with malformations, for instance because of soil compaction. Therefore, as well as for necroses due to migratory nematodes, a root section is needed for an accurate assessment of root-knot nematode attacks.

These direct methods of estimation are easy to use and enable an immediate field diagnosis. However, they have serious limitations linked with i) the subjectivity of estimation (e. g. Infestation level may be overestimated in a fairly undammaged field whereas underestimated in a heavily infested area), ii) their *post-mortem* characteristic (it is therefore too late to take action for the cycle in progress and, often, for that following).

These estimation methods are thus distinctly inadequate for experimental or monitoring purposes, and should only be used in special cases, when a more accurate assessment is not necessary or possible, for instance surveys in extensive cropping systems. For a more precise evaluation of nematode attack, identification and counting of nematodes are necessary.

ESTIMATION OF NEMATODE POPULATIONS.

This estimation can be performed from plant tissues or/and soil samples. Analyses of soil samples are usually of little value for migratory endoparasitic nematodes, i. e. Pratylenchidae. A logarithmic correlation was found between soil and root populations of *R. similis* (Ambrose, 1984). However, the fitness of this relation

is not accurate enough to estimate the root population from soil countings. For sedentary nematodes as well as for ectoparasites, counting of soil populations is necessary.

The reliability of countings is closely related to the efficiency of the following steps:

1) Field sampling
2) Extraction of nematodes
3) Counting

Errors or inaccuracies, especially in sampling of aliquot parts during the successive steps of the whole process, may accumulate to generate an important bias.

SAMPLING PLANT TISSUE

The main problem is that nematode populations are usually distributed in highly variable spatial patterns whether in roots, plants or fields) (Sarah, 1986; Hugon & Picard, 1988; Sarah & Perrier, 1988). As far as *R. similis* and banana are concerned, the standard deviation of individual sub-samplings is usually close to the mean, except for very high infestation levels. Therefore, sampling consideration is of very high importance for "catch efficiency" (Ferris, 1987).

There are two main questions:

1) Subsampling at the plant level
2) Total sample size (number of plants -subsamples- to be sampled)

Regarding subsampling at the plant level, the main problem is the heterogeneity of the banana root system, with roots linked to different generations of plant parts (old plant, mother plant, ratoons). Dynamics of populations, infestation level and ratio between species at one sampling date in the roots are dependent on root links (Cadet and Quénéhervé, 1985 and 1986; Sarah, 1986). However, the global method developed by Vilardebo and Guérout, (1974*a*) is adapted to routine estimations such as in surveys and in field trials, because it is quite simple, non-destructive at plant level, and the resulting estimations are reliable.

However, more detailed investigations on plant-parasite relationships may need a more accurate method with separate - sectorial - samplings and countings, considering roots origin (Cadet & Quénéhervé, 1986; Sarah, 1986). This kind of sampling is higly destructive and much more intensive and, thus, cannot be used for routine purposes.

Considering sample size, and using a global sampling method, it was estimated that the optimal value is 15-20 banana plants for an "homogeneous" plot or plantation unit (Sarah & Perrier, 1988). A plot is considered to be homogeneous when bananas were planted at the same date and when no gradient or heterogeneity (soil, topography, plant development...) can be seen. This optimal sample size is a balance between the need of accuracy and the amount of field work. In that case, the limits of the confidence interval of the estimated mean can be calculated using a factor of 1.3.(upper limit = m x 1.3 ; lower limit = m / 1.3).

Routine estimations on experimental plots (36 to 60 plants) are done by sampling one in four plants (9 to 12 plants at each sampling date), every one or two months with a shift of one plant each sampling time. This means that sampling at time $t+4$ will be performed on the same plants as sampled at time t. Nematode surveys on intensive cropping are performed on 15 to 20 plants per plantation unit (about one hectare). These plants are selected, whenever possible, at a definite phenological stage. Usually this sampling stage is flowering because i) it is easy to recognize, ii) there is generally a maximum level of infestation at this stage (Vilardebo, 1976; Hugon *et al.*, 1984; Sarah, 1986). In extensive cropping systems, this kind of sampling is not applicable due to the generally small number of plants. A qualitative survey, presence/absence of the nematode with

eventually an indication of its abundance, may be sufficient but, generally, the ratio of sampled plants to total plants is high enough to give a quite good idea of the degree of infestation.

EXTRACTION

Direct counting of stained nematodes in plant tissue is possible. However, this technique is applicable only to very small samples which most likely will not be representative of the population because of the patchy spatial pattern (Merny & Luc, 1966). Therefore, nematodes must be counted from a larger (more representative) sample, from which they will be extracted.

Techniques of extraction can be divided in two categories:

1) Passive extractions, which do not require activity of the nematodes;
2) Active extractions, requiring nematode mobility.

In passive techniques, nematodes are separated mechanically from their medium in two steps : dissociation (either dispersion of soil particles in water or maceration of plant tissue) then separation *sensu stricto* through density gradient (elutriation, flotation) and/or sieving. These methods are quite fast (especially when the flotation process is accelerated through centrifugation) and may give a fairly representative picture of the different species/stages (including eggs) actually present in the medium at sampling time whatever their mobility might be.

Errors or losses may accumulate during the successive steps. The dissociation may not be complete (especially if maceration is too short or too gentle) and/or some nematodes may be destroyed during the maceration process (especially if maceration is too long or too strong). The elutriation or flotation process may not separate nematodes completely from soil particles or tissue debris (especially if the dissociation was incomplete). Moreover, osmotic pressure of the solution may destroy some nematodes during the flotation process which must be shortened by centrifugation. Losses may also occur during the sieving process : part of the nematode population would stay in the upper sieve with the coarsest particles (especially if sieving time is too short) and another part would escape through the meshes of the lower sieve (especially if sieving time is too long). These losses can be limited by using meshes as small as possible. However, the smaller the mesh the weaker and the more exponentially expensive the sieve. Moreover, small meshes may be rapidly clogged up, especially by soil particles, during the process.

Among those techniques, centrifugal flotation (Coolen & d'Herde, 1972; Vilardebo & Guérout, 1974*b*) is generally considered to be one of the best for extraction of deep endoparasitic nematodes from banana tissue. However it is quite sophisticated and can be used only in well equipped laboratories. In more rustic conditions, the separation process may be simply performed by sieving alone. In that case, beside risks of loss, the counting of nematodes after sieving will be difficult because of the generally large amount of particles present in the collected suspension (see below).

In active techniques, the mobile individuals/stages go out of crumbled soil or cut/macerated tissues by themselves. Nematodes passing through a filter (thin cotton or nylon cloth or muslin, retaining soil or tissue particles) are collected at the bottom of the apparatus. Oxygenation, which improves nematode mobility, thus extraction efficiency, can be done by bubbling, addition of H2O2, continual spray of a fine water mist, or simply by increasing the ratio surface/volume of water using a shallow dish. These techniques are generally little demanding in equipment and may be used even in a highly rustic environment. On the other hand, beside the fact that they are unable to extract non-mobile species or stages, a long period of time (up to several weeks) is needed to complete the extraction of the active population.

IMPORTANCE OF STORAGE CONDITIONS

If a large number of samples is to be analysed, the complete process may take a long time (several days or even weeks) which leads to a biased estimation, the population usually decreasing during storage. Low temperature, 10 to 20 °C, can slow down the decrease. As shown by studies conducted in Guadeloupe, freezing of roots samples allows a long term storage with no detectable loss (Simon, unpublished). Since a 25-50 g aliquot part only is frozen, there is less of a problem of storage space requirement.

COUNTING

Extracted nematodes are collected in 100 to 200 ml of water from which an aliquot part of only 1 to 5 ml will be used for counting. Thus homogenization of the nematode suspension is of prime importance. Since counting can be a drudger, human errors may occur. Reliability can be largely improved by good quality lenses, a suspension free of debris, monospecific population and a "reasonnable" number of nematodes (i.e. 20 to 100 nematode/ ml). If the number of nematodes is to high, or too low, it will be necessary to dilute or concentrate the fraction, but this operation add one more error factor.

When extractions have been done only by sieving, the collected fraction will contain large amounts of debris. It is therefore useful to use methylen blue to differentiate nematodes from tissue debris.

CONCLUSIONS

Many sources of error occur and at each step of the process of estimation of nematode density. The reliability (accuracy and repeatability) of this estimation will depend on the care taken in realising the successive operations and on strict standardization of the techniques.

Sampled plants must be selected with non-subjective criteria : randomly or sequentially (e. g. one every four plants), on total plants or among those which are at a given phenological stage.

The number of sampled plants will depend on the size of the plot, the sampling technique but also on equipment and human resources. Generally below 15 plants, the confidence interval of the estimed population density increases sharply.

Storage of the samples must be for as short a time as possible and in environmental conditions that slow down plant decay and limit dehydration of samples. Freezing of the samples is recommanded whenever possible.

Extraction errors deal with i) selected aliquot parts of the field samples, ii)losses during the successives operations, iii) human errors. Sophistication and standardization of the extraction methods will reduce nematodes losses but may increase the risk of human errors.

Human errors are the major risk when counting. It is important that the operator is working in confort during this operation, so as to limit misevaluations.

Globaly, all these sources of error will accumulate and could lead to a highly biased estimation. Even if error and losses are minimized, an exact count of the population is impossible. However respecting some basic rules (care and standardization) representative and repeatable estimations will be obtained.

ANNEXE 5

A RESEARCH COORDINATION MEETING FOR BIOLOGICAL AND INTEGRATED CONTROL OF HIGHLAND BANANA AND PLANTAIN PESTS AND DISEASES

12-14 November 1991
IITA Biological Control Center for Africa
Cotonou Benin

AGENDA

TUESDAY 12 NOVEMBER

A. Introduction
Moderator: D. Vuylsteke

Welcome address	K. Dramane	9:00 - 9:15
BCP Research and Objectives	H.R. Herren	9:15 - 9:45
Meeting Objectives	C.S. Gold	9:45 - 10:00
BREAK		10:00 - 10:30

B. International Programs
Moderator: W. Hammond

INIBAP	G. Sery	10:30 - 10:40
IITA Plantain Program	D. Vuylsteke	10:40 - 10:50
BCP Banana Weevil Project	C.S. Gold	10:50 - 11:00
ICIPE Weevil/Nematode Project	K.V. Seshu Reddy*	11:00 - 11:10
CRBP	A. Lassoudiere	11:10 - 11:20
IRFA	J.L. Sarah	11:20 - 11:30
CABI	J. Bridge	11:30 - 11:40
NRI	S. Gowen	11:40 - 11:50
Discussion		11:50 - 12:10
LUNCH		12:10 - 13:30

C. Regional and Country Constraints
Moderator: G. Sery

Ghana	K. Afreh-Nuamah	13:30 - 13:40
Gabon	J. Boussienguet	13:40 - 13:50
Uganda	E. Karamura	13:50 - 14:00
Tanzania	N.D. Rukazambuga	14:00 - 14:10
Great Lakes	F. Gatsinzi	14:10 - 14:20
Rwanda	T. Musabyimana	14:20 - 14:30
Summary	G. Sery	14:30 - 14:45
Discussion		14:45 - 15:00
BREAK		15:00 - 15:30
Set up Working Groups[1]		15:30 - 17:00

WEDNESDAY 13 November

D. Survey and Assessment Activities

Moderator: E. Karamura

RRA (Uganda)	C.S. Gold	8:30 - 8:45
Pests Surveys (Tanzania)	J. Bridge	8:45 - 9:00
Pest/Disease Surveys (Rwanda)	T. Musabyimana	9:00 - 9:15
Nematode Surveys (Cameroon)	J. Bridge	9:15 - 9:30
Survey Site Selection	S.S. Jagtap	9:30 - 9:50
Discussion		9:50 - 10:20
BREAK		10:20 - 10:50

E. Research Reports

1. Banana Weevil
Moderator: C. Lomer

Varietal Screening	R. Fogain**	10:50 - 11:05
Weevil Trapping Studies	N. Price	11:05 - 11:20
Population Assessment	K. Afreh-Nuamah	11:20 - 11:35
Semiochemicals	B. Budenberg	11:35 - 11:50
Endemic Natural Enemies	A. Koppenhoffer	11:50 - 12:05
Weevil Parasitoids	G. Boivin	12:05 - 12:20
LUNCH		12:20 - 13:50
Botanic Insecticides	M. Walangulu	13:50 - 14:05
Pathogen Assessment	G. Allard	14:05 - 14:20
Weevil Pathogens/Nematodes	J. Pena	14:20 - 14:35
Cultural Controls	K.V. Seshu Reddy*	14:35 - 14:50
Discussion		14:50 - 15:10
BREAK		15:10 - 15:40

2. Nematodes
Moderator: G. Boivin

Distribution	J. Bridge	15:40 - 15:55
Economic Loss/Management	S. Gowen	15:55 - 16:10
Biology/Sampling Methods	J.L. Sarah	16:10 - 16:25
Host Phenology and Nematodes	P. Queneherve	16:25 - 16:40
BREAK		16:40 - 17:10
Nematode/Fusarium Interactions	P. Speijer	17:10 - 17:25
Biological Control of Nematodes	J. Coosemans	17:25 - 17:40
Discussion		17:40 - 18:00
Informal Meeting of Working Groups		20:15 - 21:30

THURSDAY 14 NOVEMBER

3. Pathogens
Moderator: J.L. Sarah

Host Plant/Disease	C. Pasberg-Gauhl	8:30 - 8:45
Black Sigatoka Epidemiology	F. Gauhl	8:45 - 9:00
Yellow Sigatoka Epidemiology	E. Foure	9:00 - 9:15
Sigatoka Assessment	J. Waller***	9:15 - 9:30
Fusarium Wilt	R. Ploetz	9:30 - 9:45
Breeding Strategies	D. Vuylsteke	9:45 - 10:00
Discussion		10:00 - 10:30
BREAK		10:30 - 11:00

F. New Projects/Proposed Research
Moderator: P. Speijer

Secondary Host Association	L. Traore	11:00 - 11:10
Nematode Profiles	I. Kashaija	11:10 - 11:20
Weevil-Host Plant	D. Rukazambuga	11:20 - 11:30
Pathogen Assessment	W. Tushemereirwe	11:30 - 11:40
Discussion		11:40 - 12:00
LUNCH		12:00 - 13:30

G. Discussions/Coordination/Recommendations

Discussion: Assessment Methods	13:30 - 14:30
Working Groups	14:30 - 16:30
Plenary Session	16:30 - 18:00

[1] Working Groups
Group 1: Banana Weevil
Group 2: Nematodes
Group 3: Pathogens

* Paper presented by A. Koppenhoffer
** Paper presented by N. Price
*** Paper presented by G. Allard

BP 3
34981 St GELY du FESC Cedex
Tél. 67 84 86 20